Appln No. 09/194,664
Amdt. Dated March 15,2005
Reply to Office Communication of 02/16/05
Docket No. RD-25654

Amendment to the Claims:

This listing of claims will replace all prior versions, and listings, of claims in the application.

Listing of Claims:

1 (currently amended): A method for producing axially symmetric parts from multiphase alloys comprising the steps of:

(a) shaping an axially symmetric billet of the part being produced by rolling the billet, while rotating about its own axis, with at least one roll which has at least three degrees of freedom, under controlled conditions for shaping the billet being processed, the conditions including strain-temperature-and-rate, the billet temperature, the load application pattern and the value of the load applied, the conditions determining the level of internal stresses in the billet and the level of the material strain resistance, at a billet temperature above 0.4 melting point of the multiphase alloy but below a temperature at which a total content of precipitates or an allotropic modification of a matrix of the multiphase alloy is not below about 7%, with a tool load of q of the roller, and meeting the following conditions:

$$\sigma_{SH} > q \geq \sigma_{S\Delta}$$

$$K \bullet \sigma_{S\eta} > q$$

where:

$\sigma_{S\Delta}$ is the [-] yield stress of the material of the billet portions subject to deformation;

σ_{SH} is the [-] strain resistance of the material of the billet portions not subject to deformation;

$K \leq 2$, is an empirical coefficient; and

$\sigma_{S\eta}$ is the [-] strain resistance of the tool material at a strain temperature of the billet under process [,] ;

with the strain rate in the range from about 10^2 to about $10^{-3}\ s^{-1}$; and then

heating the part to a temperature above or below a dissolution temperature of a second phase or allotropic modification depending on a microstructure of the material of the axially symmetric part resulting from the rolling procedure.

2 (original): A method as set forth in claim 1, wherein rolling of the billet is preceded by a plastic deformation of a central portion of said billet by compressing with tail spindles which are then used for billet rotation.

3 (original): A method as set forth in claim 1, wherein the billet is rolled by at least one pair of rolls, each roll in the pair exerting approximately the same force as the other roll of the pair.

4 (currently amended): A method as set forth in claim 3, wherein the load moments for each pair of rolls are mutually balanced in accordance with the following relationship:

$$q_i \bullet S_i \bullet L_i = q_{i+1} \bullet S_{i=1} \bullet L_{i=1}$$

where q_i and q_{i+1} are specific load of the rolls,

S_i and S_{i-1} are billet-to-rolls contact are,

L_i and L_{i-1} is the distance from the center of gravity of the contact are to the center of billet rotation, and

i is 1, 2, 3, ... number of rolls.

5 (original): A method as set forth in claim 1, wherein rolling is accompanied by clockwise rotation of the billet and rolls at about equal speeds.

6 (original): A method as set forth in claim 1, wherein parts of a disk type are rolled by radially displacing the rolls forming the inner surface of the disk rim, relative to each other while retaining their mutual overlapping of the rolled area.

7 (original): A method as set forth in claim 1, wherein parts of the disk type are rolled with at least three rolls of which two rolls form the inner disk surface, while the third roll forms the disk rim with a force not exceeding that exerted by the other two rolls.

8 (original): A method as set forth in claim 1, wherein parts of as shell type are rolled with rolls spaced differently apart from the center of the billet rotation.

9 (original): A method as set forth in claim 2, wherein parts of the shell type are rolled by displacing the tail spindles relative to the initial rolling plane.

10 (original): A method as set forth in claim 1, wherein rolling is performed with an increased speed of radial roll displacement away from the disk axis.

11 (original): A method as set forth in claim 1, wherein intricate-shaped parts are rolled with at least three rolls whose axis can rotate in the range of about 0 to 1 radian with respect to the axis of the billet rotation and make up an angle of about 0 to 2π radian with the axes of other rolls.

12 (original): A method as set forth in claim 1, wherein the billet is rolled with rolls displaced with respect to the plane passing through the billet axis.

13 (currently amended): A method for producing axially symmetric parts from multiphase alloys, comprising the steps of:

(a) preparing the billet structure by a thermo-mechanical treatment, comprising heating the billet to a temperature at which a total content of precipitates or an allotropic modification of a matrix of the multiphase alloy exceeds about 7%, followed by a stage-by-stage reduction of the treatment temperature down to a temperature of formation of a stable fine-grained microstructure, the ratio between the grain sizes for different phases not exceeding 10;

(b) subjecting the billet to deformation as each decreasing temperature stage so as to reduce a billet cross-sectional area by about 1.2 to 3.9 times per stage;

(c) further subjecting the billet to deformation while rotating the billet around its own axis, by rolling it with at least one roll which has at least three degrees of freedom, under controlled conditions for shaping the billet being processed, the conditions including strain-temperature-and-rate, the billet temperature, the load application pattern and the value of the load applied, the conditions determining the level of internal stresses in the billet and the level of the material strain resistance, at a billet temperature above 0.4 melting point of the multiphase alloy but below a temperature at which a total content of precipitates or precipitated phases or an allotropic modification of the matrix of the multiphase alloy is not below 7%, with a tool load of q of the roller meeting the following conditions:

$$\sigma_{SH} > q \geq \sigma_{S\Delta}$$

$$K \bullet \sigma_{S\eta} > q$$

where:

σ_{SH} is the [-] strain resistance of the material of the billet portions not subject to deformation;

$\sigma_{S\Delta}$ is the [-] yield stress of the material of the billet portions subject to deformation;

$\sigma_{S\eta}$ is the [-] strain resistance of the tool material at a strain temperature of the billet under process [,] ;and

$K \leq 2$, is an empirical coefficient;

with the strain rate in the range from about 10^2 to about $10^{-3}s^{-1}$; and then

(d) heating the part to a temperature above or below the dissolution temperature of the second phase or allotropic modification depending on a microstructure of the material of the axially symmetric part resulting from the rolling procedure.

14 (original): A method as set forth in claim 13, wherein the billet is imparted, at step (a) of preparing the billet structure, the shape corresponding to that of the axisymmetrical part produced.

15 (original): A method as set forth in claim 13, wherein a stage-by-stage reduction of the treatment temperature of the billet from nickel-based alloys is performed by providing a maximum increase in the amount of the γ-phase at each stage up to and including about 14%, and each stage of the thermo-mechanical treatment is followed by a post-deformation annealing at a temperature not exceeding the temperature of the beginning of deformation at a preceding stage of treatment.

16 (currently amended): A method as set forth in claim 13, wherein the strain rate at the first treatment stage ranges from about 10^2 to about $10^{-3}\ s^{-1}$, and the strain rate at the following stages is in accordance with the following relationship:

$$\varepsilon_{\eta} = K_{\varphi} \bullet \varepsilon_{\eta\rho} \bullet T_{\Delta} / T_{\eta\rho\varphi}$$

where:

ε_{η} is the [-] strain rate at a next stage;

$\varepsilon_{\eta\rho}$ is the [-] strain rate a preceding stage;

T_{Δ} is the [-] deformation temperature;

$T_{\eta\rho\varphi}$ is the [-] temperature of the second phase complete dissolution; and

K_{φ} is [-] 2.

17 (currently amended): A method as set forth in claim 1, wherein the rolling of billets from age-hardenable alloys is preceded by annealing the billets in a monophase region at a temperature not exceeding 1.07 the temperature of the γ-phase complete dissolution, followed by cooling down to a temperature not above the rolling temperature at a cooling rate that ensures an increase in the amount of the γ-phase fro 5% per hour to 50% per hour, and postrolling heat treatment of the part is carried out at a temperature of the γ-phase complete dissolution.

18 (original): A method as set forth in claim 1, wherein the rolling procedure is preceded by annealing at least two billet portions so as to establish a temperature gradient, the temperature being changed in the range from about 0.8 the temperature of

the γ-phase complete dissolution in one billet portion to a temperature not above 0.7 the temperature of the γ-phase complete dissolution in the other billet portion, followed by cooling down to a temperature not above the rolling temperature at a rate that ensures an increase in the amount of the γ-phase from 5% per hour to 50% per hour, and postrolling heat treatment of the part is carried out at a temperature below the temperature of the γ-phase complete dissolution.

19 (original): A method as set forth in claim1, wherein the rolling procedure is performed in two stages at the first of which the billet is subjected to deformation in a temperature range of superplasticity until the billet size gets equal to 0.6-0.9 of the part final size, after which the entire billet or its nonrolled portion is annealed in a monophase region, followed by cooling the billet from the annealing temperature down to a temperature not above the rolling temperature at a rate that increases an amount of the γ-phase form 5% per hour to 50% per hour, whereupon the billet is rolled to the part final size and heat-treated at a temperature below the temperature of the γ-phase complete dissolution.

20 (original): A method as set forth in claim 1, wherein at least two adjacent billet portions are rolled at different deformation ratios that vary steadily from one billet portion to the another by 0.25 to 0.75 the deformation ratio of the adjacent billet portion.

21 (original): A method as set forth in claim 13, wherein the thermo-mechanical treatment of the billet from age-hardenable alloys is followed, before the rolling procedure, by annealing the billet in a monophase region at a temperature not exceeding 1.07 he temperature of the γ-phase's complete dissolution, followed by cooling the billet from the annealing temperature down to the temperature not above the rolling temperature at a rate that ensures an increase in the amount of the γ-phase from 5% per hour to 50% per hour, and the postrolling billet heat-treatment is carried out at a temperature below the temperature of the γ-phase complete dissolution.

22 (original): A method as set forth in claim13, wherein the thermo-mechanical treatment of the billet from age-hardenable alloys is followed by annealing aimed at establishing a temperature gradient, the temperature being changed in the range from about 0.8 the temperature of the γ-phase's complete dissolution in one billet portion to a temperature not above 1.07 the temperature of the γ-phase's complete dissolution in the other billet portion, followed by cooling down to a temperature not above the rolling temperature at a rate that ensures an increase in the amount of the γ-phase from 5% per hour to 50% per hour, and postrolling heat treatment of the part is carried out at a temperature below the temperature of the γ-phase complete dissolution.

23 (original): A method as set forth in claim 13, wherein the thermo-mechanical treatment of the billet from age-hardenable alloys is followed by its rolling in two stages at the first of which the billet is subjected to deformation in a temperature range of susperplasticity until the billet size gets equal to about 0.6-0.9 of the part's final size, after which the entire billet or its nonrolled portion is annealed in a monophase region, followed by cooling the billet from the annealing temperature down to the temperature not above the rolling temperature at a rate that ensures an increase in the amount of the γ-phase from about 5% per hour to 50% per hour, whereupon the billet is rolled to the part's final size and heat-treated at a temperature below the temperature of the γ-phase complete dissolution.

24 (original): A method as set forth in claim 13, wherein at least two adjacent billet portions are rolled at different ratios that vary steadily from one billet portion to the another by about 0.25 to 0.75 the deformation ratio of the adjacent billet portion.

Claims 25 – 30 (canceled).